Subject: PCA Comments on Final Report of the National Construction Safety Team on the Collapse of the World Trade Center Towers (Draft)
From: "Szoke, Stephen" <SSzoke@cement.org>
To: <wtc@nist.gov>

Please find the comments prepared by the Portland Cement Association attached. Thank you for this opportunity.

Steve

Stephen S. Szoke, P.E.
Director, Codes and Standards
Portland Cement Association
5420 Old Orchard Road
Skokie, Il 60077
847-972-9078
sszoke@cement.org

 WTC12 Comments 050727 FINAL.doc

Portland Cement Association
Comments on
NIST NCSTAR 1 (Draft)
Federal Building and Fire Safety Investigation of the World Trade Center Disaster
Final Report of the National Construction Safety Team on the Collapse of the World Trade Center Towers (Draft)

Contact
Stephen S. Szoke, P.E.
Director, Codes and Standards
Portland Cement Association
5420 Old Orchard Road
Skokie, IL, 60077
847-972-9078
sszoke@cement.org

Introduction

Portland Cement Association is a non-for-profit association founded in 1916 representing the portland cement manufacturers in the United States and Canada. To accomplish its mission: "*Improve and expand the uses of portland cement and concrete*," PCA conducts market development, engineering, research, education, and public affairs programs. PCA actively participates in the development of model building codes and reference standards and is an American National Standards Institute (ANSI) accredited national standards writing organization. The following comments on the Final Report of the National Construction Safety Team on the Collapse of the World Trade Center Towers (Draft) are offered by PCA to improve the fire safety of buildings and to correct misconceptions.

General Comments

G-1. PCA applauds NIST for its efforts in the development of this report and the recommendations. PCA will continue its efforts, many of which are consistent with the recommendations of the report, to influence model building codes and national reference standards for increased life safety, property protection, and welfare of the general public. To that end, PCA will work with NIST and organizations involved in model building codes and reference standards development to ensure that economical and effective provisions consistent with the intent of the model building codes and reference standards writing organizations and the mission of PCA are developed and incorporated into such codes and standards.

G-2. PCA recognizes that the report on World Trade Center Building 7 will be prepared separately and plans to provide comments on that report when it becomes available. PCA reiterates its concern that the resources and scope of the evaluations were limited only to buildings that collapsed on September 11, 2001. PCA recognizes that setting priority under the constraint of limited resources caused a perceived need to focus on those buildings that collapsed, but we continue to believe that an opportunity to identify building designs and construction practices that performed exceptionally well was lost due to the limited scope. For example, 90 West Street was damaged by debris from the collapse of nearby structures and fires spread throughout the building. This building did not collapse and has since been renovated and is now being re-occupied.

G-3. PCA remains concerned that there will be continued resistance to improvements in life safety, property protection, and welfare of the general public in future developments of the model building codes and reference standards. Many of the recommendations that relate to technical provisions of building codes have been discussed in the model code development arenas for the past several decades, including during the development and subsequent changes to the first

edition of the International Code Council's *International Building Code* and National Fire Protection Association's *Building Construction and Safety Code*, NFPA 5000. PCA and its allies in the cement-based product industries have initiated many of these discussions via code change proposals. Such proposals have attempted to strengthen code provisions by increasing the required fire resistance rating of the structural frame; eliminating sprinkler trade-offs; improving compartmentation by increasing the required fire resistance rating and/or requiring fire resistance rated barriers where codes presently do not require rated walls, with specific emphasis on exit stairway walls; and by modifying the hose stream test of American Society for Testing and Materials (ASTM) *E 119 Standard Test Methods for Fire Tests of Building Construction and Materials* to require the more rigorous test for all specimens. Almost all of these proposals have been disapproved. The reason generally cited for their disapproval is that fire data do not indicate a need for change.

G-4. Mandatory requirements for reporting the performance of building construction in fire scenarios are needed to substantiate revisions to model building codes and reference standards. Mandatory requirements for reporting the performance of building construction are missing components of the United States Fire Administration's (USFA) National Fire Incidence Reporting System (NFIRS). Methods other than NFIRS and/or the use for fire services to accurately identify building construction, evaluate the performance of building construction, retain a database, and report findings may be required.

G-5. PCA encourages efforts to ensure that building collapse does not result due to fire exposure. It appears that fire, with the exception of wildland interface fires, are generally considered local disasters. Therefore, they do not qualify for national disaster assistance, and do not receive the same attention from Federal agencies as other disasters such as high wind and seismic events even though more life and property losses occur annually in these isolated incidences than in most events that may be classified as national disasters. There are higher priorities by Federal agencies on flood, wildland fires, high-wind, and seismic disasters, than for local structure fires. This is likely attributed to major flood, wildland-fire, high-wind and seismic disaster areas being made national disaster areas which are eligible for Federal financial assistance for disaster mitigation and recovery. These priorities may have resulted in a lack of Federal programs for disaster prevention and recovery due to structure fires. It is disappointing that Federal assistance programs for improving life safety and property protection from isolated fire incidents are almost nonexistence when compared with Federal assistance programs than for high wind and seismic mitigation and recovery, especially when structure fires (excluding fires in one and two-family dwellings) annually result in more deaths, injuries, loss of property, and loss of business.

G-6. Consistent units should be used throughout the document. The document currently contains a combination of in-pound and metric units. In the in-pound system temperatures are expressed in °F not °C. If metric units need to be shown, it might be best to place them in parentheses behind the in-pound units.

Specific Comments

Summary of Findings:

S-1. *Page xliv, Objective 2, fourth bullet:*
Inadequacies of the structures to accommodate evacuation in a timely fashion are discussed. There should be provisions in section 9.2.5 "Group 5 Improved Building Evacuation" for the development of models used to predict building evacuation.

S-2. *Page xlv, Objective 2, last bullet:*
The time required for emergency responders to reach destinations within the damaged structures is discussed. The provisions in section 9.2.6 "Group 6 Improved Emergency Response" should include the development of models to predict the response time for emergency responders to reach destinations to perform tasks including time to assist others to evacuate.

S-3. *Page xlix, Table E-1:*
This table calls for New Methods for Fire Resistant Design of Structures to achieve burnout without local or global structural collapse in uncontrolled building fires. Buildings surrounding the WTC towers experienced burnout and did not collapse. The robustness of building elements and the ability of building elements to assist in transferring loads and limiting deflections appear to have played a significant role in allowing such buildings as 90 West Street to be reoccupied. The approach throughout this document appears to focus on individual components consistent with the recent and current trends in model building code and reference standard development. The use of individual building elements for multiple purposes and the use of multiple structural elements within buildings do not appear to be adequately addressed in the recommendations of this report. For example, when masonry walls are placed between structural elements, they are providing compartmentation in addition to limiting deflections at high temperatures, providing additional protection to structural elements, and may be transferring loads to other structural elements. The report does not appear to provide adequate recommendations for combining various structural systems. For example, comprehensive designs of buildings with steel exterior structural elements and concrete or masonry cores are not addressed. In addition, the report does not provide adequate recommendations for providing built-in redundancies by combining active and passive fire protection.
Also, when fire resistance requirements were first developed for building construction, the majority of the fire protection was provided by robust concrete and masonry elements that provided additional benefits to the structure including increased robustness and structural integrity. These benefits appear to have been jeopardized with recent trends in design which focused on developing the least expensive and lightest weight systems to satisfy the fire endurance requirements of the standard fire test, ASTM E 119. A robustness component for all passive fire protection, including sprayed-on fire resistive materials (SFRM), may be needed.

Chapter 1

S-4. *Page 10, line 8:*
Editorial – Change "bending loads" to "floor loads" or "bending moments."

Chapter 5

S-5. *Page 53, Section 5.2.2 "Pertinent Construction Provisions:"*
This section provides a comparison of three building codes in place elsewhere in the United States at the time the twin towers were designed and erected. However, the comparisons appear to be limited to structural design loads. The fire protection provisions of these codes also differed. For example the 1967 Municipal Code of Chicago would have classified this structure as an E occupancy and would have required Type I-A construction due to the building's unlimited floor area and height. The use of Type 1-B construction would have limited the building to 12 stories. In this 1967 code for Type 1-A construction, all columns, interior and exterior, except those supporting the roof, required a 4-hr rating. Similarly, beams and girders, except those supporting the roof, required a 3-hour rating.

S-6. *Page 68: Section 5.6 "Passive Fire Protection:"*
The title of this section should be revised. The discussions are limited to the fire protection of steel columns which do not address other passive fire protection. This may lead to unintended misinterpretations that passive fire protection in general may be inadequate. To be consistent with the terminology of ASCE 29, it is suggested that "Passive Fire Protection" be replaced with "Fire Protection of Structural Steel." Discussion in this section might also include statements that SFRM was selected for this project in lieu of other fire protection methods such as encasing structural steel in concrete or masonry. Substantiation for such discussion may have been discovered if the scope of the report on the performance of buildings impacted by the events of September 11, 2001 included the buildings that did not collapse, such as 90 West Street.

S-7. *Page 74: Section 5.7 "Concrete:"*
This section should emphasize that the weakened steel floor trusses resulted in excessive sagging in the floor system. Since trusses were quite deep, the thin 4" concrete floor remained in compression and likely prevented the trusses from complete collapse. Without such clarification, it may be interpreted by readers that structural concrete floor members failed.

Chapter 6 – Reconstruction of Collapse

S-8. *Page 101, Line 2, "Phase 2: Major Subsystem Analyses:"*
There is discussion about "insulation damage due to shock and subsequent vibrations as a result of aircraft impact or concrete slab cracking and spalling..." The latter may be of importance in existing fire test standards and reporting. During the NIST floor system fire tests at Underwriters Laboratories a comment was made by an unidentified researcher (not with UL) suggesting that some SFRM manufacturers specify a concrete with aggregates and water contents to minimize shock and vibration at elevated temperatures. This is done to minimize the amount of SFRM that is dislodged during tests. Such test results of the steel systems with SFRM, based on fire testing with concrete designed to produce minimal shocks, might be inappropriately applied for steel floor systems regardless of the type of concrete actually used for a specific project.

S-9. Page *119: Section 6.10.2 "Modeling Approach:"*
The modeling approach includes the influence of debris from wallboard, concrete, ceiling tile and other non-combustibles. It is not clear if the 4 lb/ft^2 tenant fuel load in section 6.10.3 "The Four Cases" included the effects of the debris on ignition and combustion of building contents, altering the fire load.

Chapter 8 – Principal Findings

S-10. *Page 179: Section 8.3.4 "Reconstruction of the Fires"*
In the fifth bullet there is discussion of the fire load at 4 lb/ft^2. It is unclear if this load includes the effects of non-combustible dust and debris described in the comment above.

Chapter 9 – Recommendations

S-11. *Page 197: Section 9.1 "Building Standards and Codes: Who Is In Charge?"*
Discussion in the third paragraph is misleading. While 45 states plus the District of Columbia have adopted the International Building Code (IBC), the IBC is not applied to all buildings in these 45 states. Only seventeen states have a state-mandated building code covering all buildings and occupancy classifications. One of these seventeen is California, which has not adopted the IBC. Eighteen states do not have a state-mandated building code covering residential and commercial building other than one and two-family dwellings. Twelve of these eighteen states are listed as having adopted the IBC on the International Code Council web-site. Several states have adopted the IBC only for state-owned buildings, state-funded buildings, or for special occupancies, which in some states may be limited to multi-family construction. The statement without clarification overstates the trend toward a national building code, suggesting that 45 of 50 states have adopted the IBC. In fact some state legislation clearly states that if a jurisdiction adopts a building code it must be the state code based on the IBC, but there are no requirements for a jurisdiction to have a building code. It is also noteworthy that only 10 states do not allow amendments to their building code. According to the Institute of Business and Home Safety, 14 states allow local amendments that are more stringent then the state-mandated code and 4 allow amendments that are less stringent than the state-mandated code. Furthermore, local jurisdictions may adopt ordinances, not part of the building code, to further regulate building design and construction. PCA believes these local variations are extremely important for local jurisdictions to adequately provide life safety, property protection, and welfare of the general public in a fashion that best suits the needs of the community. There may be building height restrictions due to limitations in the equipment of fire services. There may be restrictions due to inadequate water resources. There may be amendments because of the differences in volunteer fire services versus paid fire

services. Another variation that might warrant amendments is the distance from fire stations to community boundaries. Amendments might be warranted due to variations in local geologic, topographic and climatic conditions. Each jurisdiction needs to be able to amend the model building codes to appropriately address these local conditions. PCA continues to work with both the ICC and NFPA for the development of minimum model codes to be used as the base requirements for their state or local building code adoption. PCA encourages amendments to model building codes at the state and local levels when the minimum provisions of a model code do not adequately satisfy the requirements of a community to function in a safe and productive manner due to resource and/or equipment limitations or economic, geologic, topographic, climatic, or other considerations.

S-12. Page *198, Line 20, Section 9.1 "Building Standards and Codes: Who Is In Charge?"*
This section contains a statement "Due to limited participation of the general public and building occupants, NIST has a responsibility to represent the public's interest." Is this statement accurate? If this statement is accurate, what process does NIST have in place to assure its actions and activities are representing the public's interest?

S-13. *Page 200, Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Item 2:*
This section needs to be expanded to include an evaluation of the performance criteria of typical construction historically tested in ASTM E 119 tests. Through such an evaluation, fire endurance tests may be found to be adequate. Whereas, the more significant aspect might be related to robustness or other criteria which may not be adequately addressed in the current ASTM E 119 test methods.
Discussion of "structural frame" is limited to girders, beams, trusses and spandrels. This excludes some concrete and most masonry components. Composite structures of concrete, steel, and/or masonry should be addressed for all buildings, especially those 20 stories or more in height. Concrete or masonry shear walls or masonry infill between structural members intended to serve primarily as fire protection or for compartmentation may limit deformations of, reduce temperatures of, and transfer loads from girders, beams, trusses, spandrels, and columns which are subjected to excessive loads. It may be more practical to transfer loads through elements primarily intended for fire safety than to incorporate other redundancies into the structural design of the building.
If existing fire resistance test methods are discovered to warrant revision, provisions should be incorporated into the recommendations that call for developing a methodology that can demonstrate compliance using test results obtained from existing test standards. Without such a tool, the costs to industry for retesting all assemblies would be more than each industry segment can bear. PCA recognizes that several aspects of the existing standard fire test method (ASTM E 119) may warrant revision. Examples include standardized design, construction, and operation of the furnace; and replacing the time-temperature curve with fuel load which would isolate the fuel load of the test specimen. To date, any significant revisions to the fire test standard have been slow, primarily because of the potential cost of re-testing thousands of materials, assemblies, and configurations.
Collection of data regarding the fire performance of building construction after actual structure fires would be useful in determining if priorities should be placed on revision of existing fire endurance test procedures themselves or the development of additional test methods to determine the robustness of passive fire protection.

S-14. *Page 200, Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Item 3:*
PCA strongly supports the design of structures to resist collapse after complete burnout. Such structures exist, as documented by the re-occupancy of 90 West Street.

S-15. *Page 200, Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Items 3 and 4:*
There is a need for further evaluation and development of provisions to address balanced design for fire safety with appropriate redundancies not only for structural elements and systems and for active fire suppression systems, but also for combining active fire suppression and passive fire protection.

S-16. *Page 200, Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Item 5:*
Improved building evacuation will benefit from more robust egress routes including corridors, stairways, and elevator shafts.

S-17. *Page 200 Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Item 6:*
Improved building emergency response access will benefit from more robust egress routes including corridors, stairways, and elevator shafts.

S-18. *Page 200 Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders:"*
This section is lacking any discussion regarding the potential impact of a building or building system collapse on adjacent buildings. Recommendations may be needed for developing a method to determine if impact on or from other buildings warrants consideration in a building design and what if any provisions might be incorporated into model building codes and standards. The collapse of WTC 1 and 2 had a significant impact on WTC 3, 4, 5, 6, and 7 and several other surrounding buildings. If all the buildings surrounding the twin towers were of similar construction as WTC 7 and not of more robust construction like 90 West Street, there might have been more building collapses as a result of the collapse of the twin towers and additional collapses from the collapse of neighboring buildings – a house of cards effect.

S-19. *Page 202, Section 9.2.1 Group 1. "Increased Structural Integrity:"*
PCA strongly encourages NIST to modify its discussion to encourage design that considers the benefits of other building components in increasing the fire endurance and structural integrity of individual components or structural systems. As previously mentioned, a properly designed fire separation partition may perform as an element to resist deflections and/or transfer loads to other structural elements when the failure conditions of a particular structural component are reached. An approach combining design of structural elements and design of fire protection features should consider the use of appropriately designed fire protection features such as elements that are used to resist collapse.

S-20. *Page 204, Section 9.2.2 Group 2. "Enhanced Fire Resistance of Structures:"*
Consider expanding this section to include identifying building construction features of interest to emergency responders. Information about the construction type, maximum compartment size, window systems, construction of egress routes and elevator shafts, and the type of fire protection (concrete or masonry versus spray-applied fire resistive materials (SFRM) would be extremely useful to emergency responders. This and related information could be maintained in the fire control room and/or in a database accessible to emergency responders.

S-21. *Page 205, Section 9.2.2 Group 2. "Enhanced Fire Resistance of Structures," Recommendation 5:*
Consider adding item "d. Develop methods for predicting the performance of assemblies tested under the existing fire test methods as if tested under any revision to the existing fire tests."

S-22. *Page 206, Section 9.2.2 Group 2. "Enhanced Fire Resistance of Structures," Recommendation 6:*
Consider adding provisions for the development of test criteria for SFRM to appropriately resist external vibrations and shock as well as vibration and shock inherent in the system as specified.

S-23. *Page 207, Section 9.2.3 Group 3. "New Methods for Fire Resistance Design of Structures," Recommendation 8:*
Consider expanding the scope of this section to buildings not defined as tall (20 stories). Prevention of collapse is important for many other buildings depending on the occupancy classification. Collapse resistance is also appropriate for buildings in close proximity to other buildings. Further collapse prevention is appropriate for any building over one story in height that is occupied by persons with physical disabilities or other impairments that restrict mobility.

S-24. *Page 207, Section 9.2.3 Group 3. "New Methods For Fire Resistance Design of Structures," Recommendation 8.*
We strongly support this recommendation for burnout without local or global collapse. Re-occupying structures after burnout is desirable and achievable, as was demonstrated by buildings surrounding the WTC site, especially 90 West Street, and more recently the LaSalle Bank Building in Chicago where the fire was confined to several floors. In the latter case there were no sprinklers. Concrete and masonry provided adequate fire protection and compartmentation, no deaths occurred and the damaged areas of the building are being retrofitted for future use.

S-25. *Page 210, Section 9.2.5 Group 5. "Improved Building Evacuation," Recommendation 16:*
There is a need for occupancy evacuation modeling procedures to determine the appropriate time requirements to assure minimum life safety. Development of work described in this section should be coordinated with Recommendation 4 on fire rating requirements.

S-26. *Page 211, Section 9.2.5 Group 5. "Improved Building Evacuation," Recommendation 17:*
There is a need for emergency responders to have access to evacuation modeling to determine the appropriate time requirements to assure that responders reach their destinations and are able to perform duties including assisting evacuation. Evacuation models should include emergency responders entering the structure while occupants are evacuating. Development of work described in this section should be coordinated with Recommendation 4 on fire rating requirements.

S-27. *Page 212, Section 9.2.5 Group 5. "Improved Building Evacuation," Recommendation 17, Item c:*
The use of scissor stairs (when credited as a single exit could) should serve as a means to physically separate first responders who are entering the building from building occupants exiting the building facilitate access.

S-28. Page 214, Section 9.2.6 Group 6. "Improved Emergency Response," Recommendation 21:
Improved and hardened egress and access routes should be included in this recommendation and Recommendation 18. Hardened passageways will help assure that routes to hardened elevators are not obstructed by debris, and if properly designed and ventilated may serve as safe havens until assistance arrives.

S-29. *Page 214, Section 9.2.6 Group 6. "Improved Emergency Response," Recommendation 21:*
Consideration should be given to the development of models for predicting access times for emergency responders. The results of such model would be useful in determining criteria in Recommendation 4. This section should be developed with Recommendation 4 on fire rating requirements.

S-30. *Page 220, Table 9.1, "Enhanced Fire Resistance of Structures:"*
Recommendations 4, 5, and 6 should be appropriate for "Selected Other Buildings." Construction classification and fire rating requirements are more appropriate for some building occupancies under 20 stories than for other building occupancies over 20 stories. Recommendation 5 on fire standards would also be applicable to buildings under 20 stories tall. The recommendations for SFRM should also be appropriate for buildings of any height.

S-31. *Page 220, Table 9.1, "Improved Building Evacuation:"*
Public education in Recommendation 16 is appropriate for "Other Select Buildings" depending on occupancy and mobility of occupants. Recommendation 18 on egress systems should be considered for all buildings regardless of height.

S-32. *Page 221, Table 9.1, "Improved Emergency Response:"*
Hardened egress routes are appropriate for "Selected Other Buildings" as well as buildings over 20 stories in height. Recommendation 24 retaining an effective uninterrupted operation of a command and control center should also be applicable to "Selected Other Buildings."

S-33. *Page 222, Table 9.2a, "Standards Affected by the Recommendations:"*
Add American Concrete Institute ACI/The Masonry Society (TMS) 216.1 – Standard Method for Determining Fire Resistance of Concrete and Masonry Construction Assemblies. This standard addresses group numbers 1, 2, and 3 and is applicable to recommendations 1, 3, 8, 9, and 11.

S-34. *Page 224, Table 9.2a, "Standards Affected by the Recommendations:"*
Add The Masonry Society (TMS): ACI 530/ASCE 5/TMS 402 Building Code Requirements for Masonry Structures. This would be applicable to group numbers 1, 2, 3, and recommendations 1, 2, 3, 8, 9, and 11.

S-35. *Page 225, Table 9-2c, "Organizations Affected by the Recommendations:"*
Add The Masonry Society (TMS) for group 8, education and training, with recommendations 29 and 30.

S-36. *Page 225, Table 9-2c, "Organizations Affected by the Recommendations:"*
Add Portland Cement Association (PCA) for group 8, education and training, with recommendations 29 and 30.